RESEARCH DEPARTMENT

The use of flexible couplings to reduce the transmission of vibrations through water pipes

TECHNOLOGICAL REPORT No. PH-6

UDC 534.834

1967/18

THE BRITISH BROADCASTING CORPORATION
ENGINEERING DIVISION

RESEARCH DEPARTMENT

THE USE OF FLEXIBLE COUPLINGS TO REDUCE THE TRANSMISSION OF VIBRATIONS THROUGH WATER PIPES

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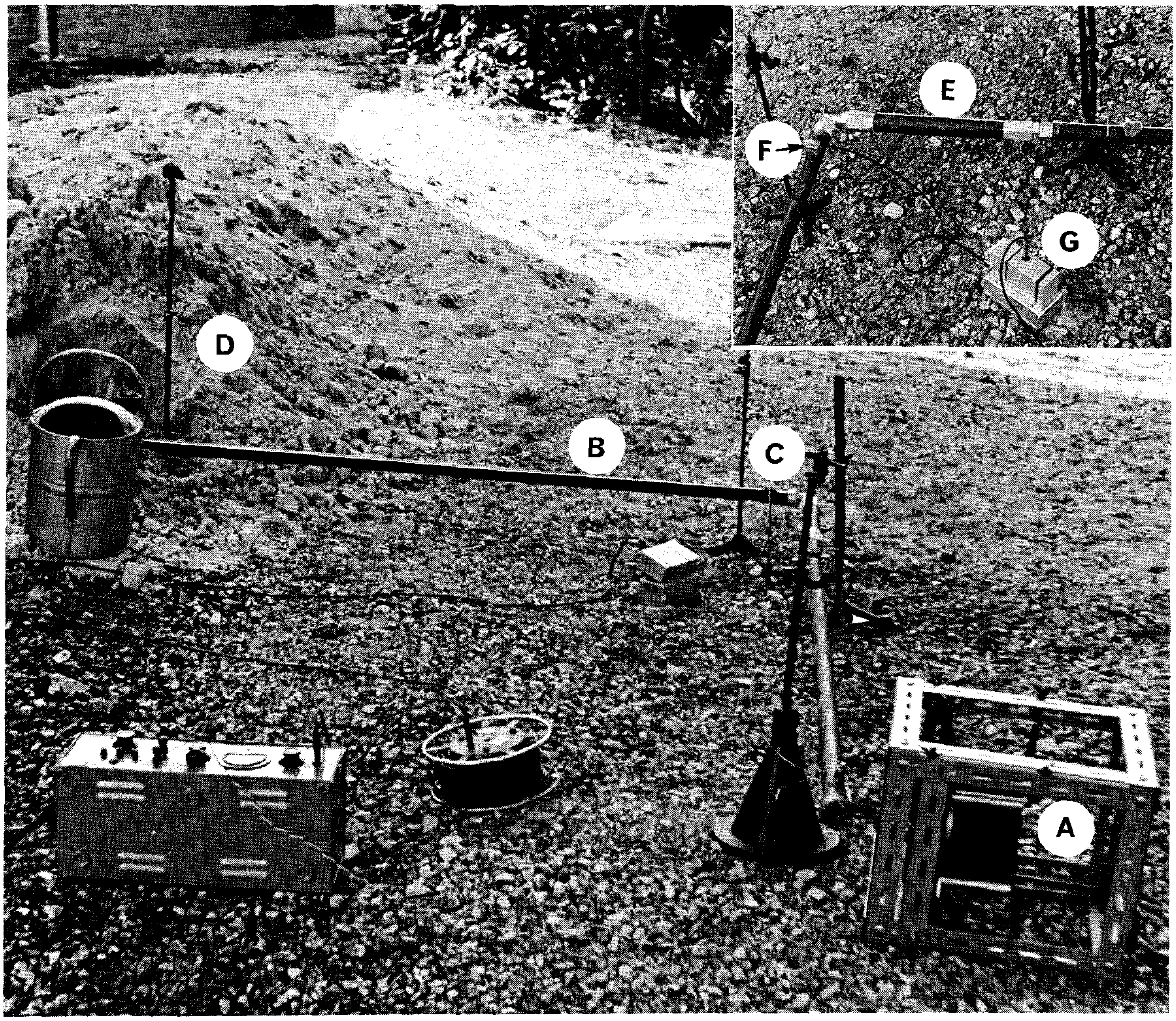

Fig. 1 - Photograph of experimental arrangement

(*A*) Vibration generator
(*B*) Pipe
(*C*) Flexible coupling
(*D*) Sand termination
(*E*) Flexible coupling
(*F*) Accelerometer
(*G*) Head amplifier

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SUMMARY

In studio centres now being built in which a combination of hot-water radiators and simple ventilation systems is used instead of complete air conditioning, vibrations transmitted along the hot-water pipe system into the studios may constitute a source of acoustic noise. This report describes a series of experiments which were undertaken to determine the reduction in noise power radiated from heating radiators when flexible couplings are inserted in the feed pipes.

1. INTRODUCTION

In studios that are heated by conventional hot-water systems vibrations caused by shock excitation of the water pipes outside the studio will be transmitted along the pipes and sound may then be radiated into the studio. The coupling efficiency between vibrating water pipes and the air in the studio will be small except for transverse vibrations of the pipe; the coupling efficiency from the radiators to the air will be greater than that from the pipes.

Section 2.1 of this report describes experiments undertaken to measure the vibration isolation provided by the insertion of steel-braid reinforced rubber couplings in the pipes. Section 2.2 deals with the effective reduction of radiated sound power from a hot water radiator when a rubber coupling section is interposed between the excitation point and the radiator.

2. EXPERIMENTAL PROCEDURE AND RESULTS

2.1. Vibration Isolation

Two 2 m lengths of nominal ¾-inch (19 mm) water pipe were supplied by Building Department, together with elbow joints and two reinforced rubber couplings. The pipes, elbow joints and couplings were assembled in various configurations and suspended by loops of waxed twine. One end of the assembly was buried in moist sand to provide a resistive termination and the other end was driven by a vibration generator to which a random noise signal was applied. The vibration generator could be aligned parallel to or perpendicular to the axis of the driven pipe. Fig. 1 is a photograph of experimental arrangement used.

Accelerometers were attached to each of the pipes at points adjacent to and on either side of the flexible couplings, and thus the transmission loss of the coupling could be simply determined. The accelerometer on the terminated pipe was always attached so that it was sensitive to vibrations perpendicular to the pipe axis, i.e. to transverse vibrations, and the accelerometer on the driven pipe was used to measure both longitudinal and transverse acceleration amplitudes. This arrangement was chosen because the coupling coefficient between vibrations parallel to the pipe axis and the air will be extremely small. Three different configurations were investigated:

(a) Two pipes connected by a single flexible coupling bent through 90°.

(b) Two pipes connected by a single flexible coupling and an elbow joint.

(c) Two pipes joined by two flexible couplings with an elbow joint interposed.

The whole system could be filled with water to find out whether the presence of water affects the performance of the couplings.

The results of these measurements are given in Figs. 2 - 5 inclusive, in which the octave-band transmission loss is plotted for the three configurations.

Fig. 2 shows the transmission loss through the single coupling bent at right angles. In curve (*a*) the pipe is empty, in curve (*b*) it is filled with water. The measurements of vibration are measured perpendicular to the axis of the pipe at both ends of the coupling. It will be seen that the water has an insignificant effect on the transmission. This conclusion is confirmed by all the measurements in

this series and the curves in subsequent figures are for filled pipes only.

Fig. 3 shows the transmission loss through the same coupling. In curve (*a*) the input end is excited transversely and measurements are made transversely at both ends of the coupling. In curve (*b*) the pipe is excited longitudinally and the transverse acceleration at the remote end of the coupling is compared with the longitudinal acceleration on the excited end.

Figs. 4 and 5 show the results in the same way for the other two configurations.

The two couplings at right angles are seen to give considerably higher transmission loss than the single coupling in either configuration. Subsequent work was therefore confined to the two-coupling arrangement.

2.2. Reduction of Radiated Acoustic Power

Having measured the vibration isolation obtainable in the three configurations of pipes and couplings, it was decided that tests could be undertaken to determine the effect of the best configuration of flexible couplings on the acoustic power radiated from a heating radiator as a result of random shock excitation of the system at a remote point. A radiator was fixed to the wall of the stair well adjacent to the Large Reverberation Room at Kingswood Warren, and the feed pipe to the radiator was passed through a hole in a partition covering the communicating doorway and having a mean sound reduction factor of 32 dB. Two flexible couplings connected by an elbow joint were used to join a second length of pipe which was suspended from twine loop and a "footsteps machine" was so mounted above the free end of the suspended pipe in such a way that the hammers fell directly on to the pipe. The octave-band sound pressure levels produced were measured in the room containing the radiator and from these measurements the radiated acoustic power levels were calculated. Fig. 6 shows the octave band analysis of the reduction in acoustic power radiated as a result of fitting the flexible couplings.

3. DISCUSSION

This investigation has shown that a worthwhile reduction in transmission of vibrations along water pipes can be achieved by inserting flexible couplings in the feed pipes outside the room. It will be seen that two flexible couplings connected at right angles provide the most useful reduction in vibration levels and that the efficiency of the flexible couplings as vibration isolators is not appreciably altered by filling the pipes with water. As a consequence of the reduced transmission of vibration through the pipe system, a considerable reduction is achieved in the acoustic power level radiated into rooms from heating radiators. This reduction in the system tested varies from 10 dB at low frequencies to 45 dB at high frequencies, and bearing in mind that the coupling efficiency between the radiator and the air will be small at low frequencies and large at high frequencies, this is a worthwhile reduction. It is suggested that the provision of flexible couplings, preferably in pairs at right angles, in the supply pipes to studios would provide adequate protection against the radiation of unwanted noise into the studio from shock excitation of the pipe systems in adjacent corridors, offices and other rooms.

4. CONCLUSIONS

The experimental work described above showed that a very worthwhile reduction of the conduction of sound and vibration into a studio through hot water pipes can be achieved by inserting steel-braid reinforced rubber couplings into the pipes outside the studio.

The most effective arrangement is to use two couplings, one on either side of a right-angle bend.

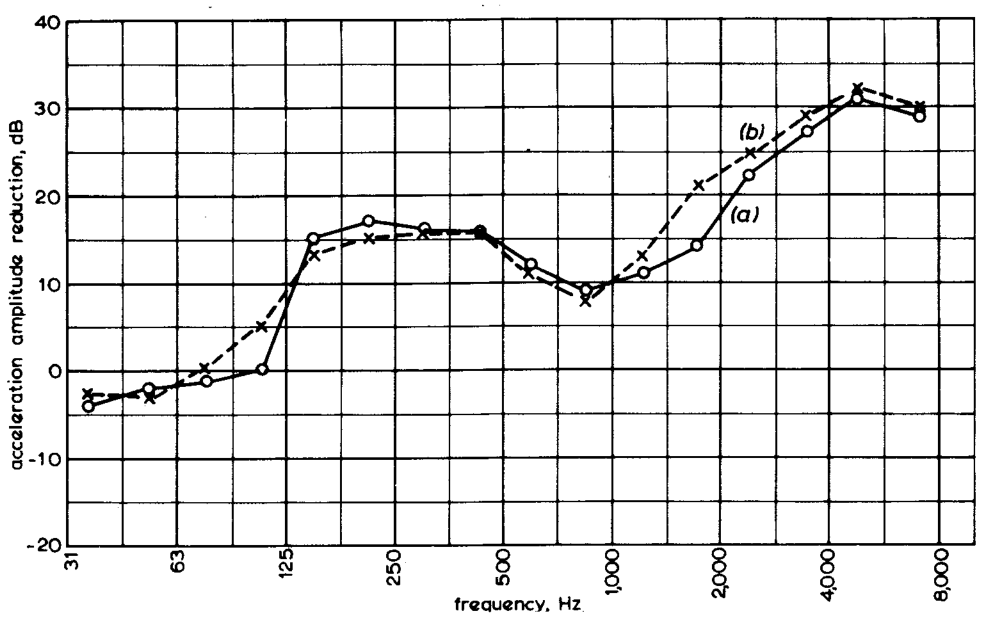

Fig. 2 - Effect of water filling on transmission loss to transverse vibrations through coupling (single flexible coupling, bent through 90°, transverse excitation)

(*a*) Without water (*b*) With water

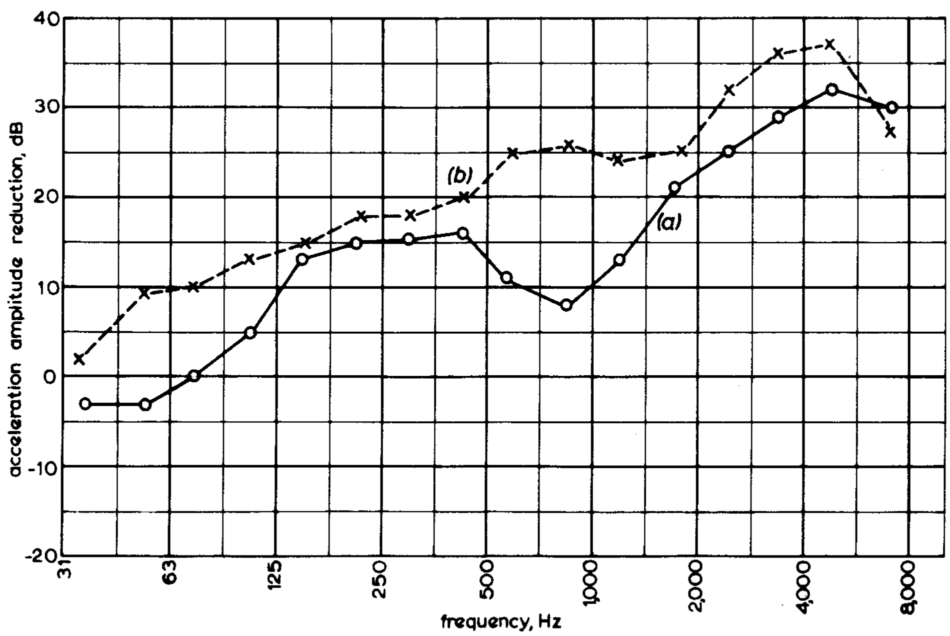

Fig. 3 - Reduction of acceleration amplitude across single flexible coupling bent through 90° (water filled)

(*a*) Transverse to transverse, with transverse excitation
(*b*) Longitudinal to transverse, with longitudinal excitation

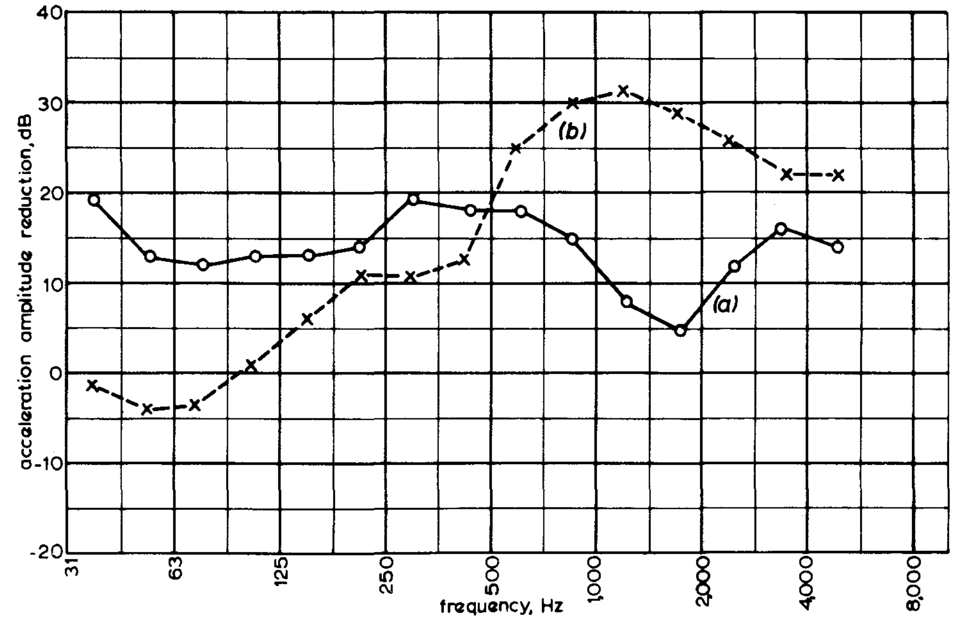

Fig. 4 - Reduction of acceleration amplitude across single straight coupling with elbow joint (water filled)

(*a*) Transverse to transverse, with transverse excitation
(*b*) Longitudinal to transverse with longitudinal excitation

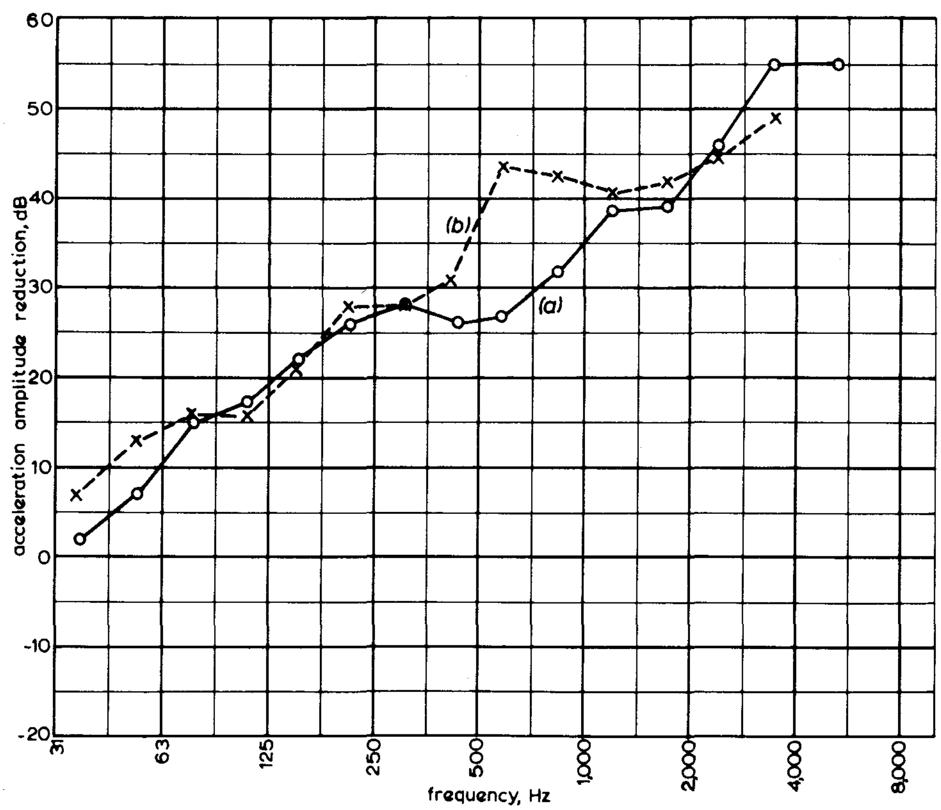

Fig. 5 - Reduction of acceleration amplitude across two flexible couplings connected by an elbow joint (water filled)

(*a*) Transverse to transverse, with transverse excitation
(*b*) Longitudinal to transverse, with longitudinal excitation

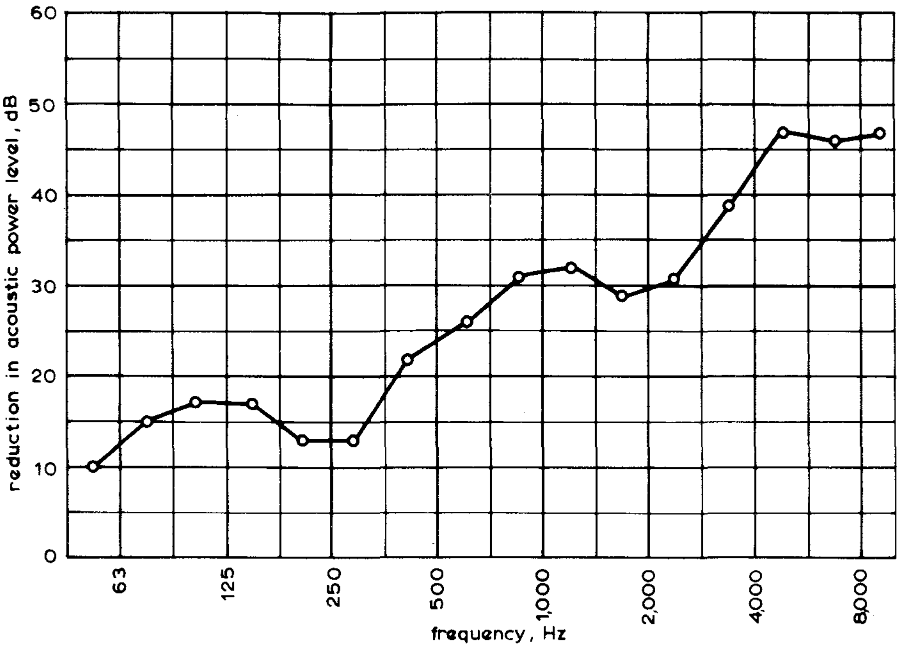

Fig. 6 - Reduction in acoustic power radiated from a hot-water radiator produced by the insertion of two flexible couplings connected by an elbow joint in the feed pipe

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